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A Review of the Safety Climate Literature as it Relates to Naval Aviation

by

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14. ABSTRACT
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The purpose of this literature review is to provide the background to an evaluation of the utility of the Command Safety Assessment Survey (CSAS) as a valid predictor of future mishaps. The end goal is to be able to use the survey to identify "at risk" U.S. Naval squadrons prior to the occurrence of mishaps. Safety climate describes employees' perceptions, attitudes, and beliefs about risk and safety (Mearns & Flin, 1999). Safety climate is most commonly evaluated using questionnaires. Although assessments of safety climate are not widespread in civil aviation, the United States Navy has been using the CSAS since 2000 to measure the safety climate of aviation squadrons. This review argues that a comprehensive assessment of the construct (the extent to which the questionnaire measures what it is intended to measure) and discriminate validity (correlate the data from the questionnaire with a criterion variable, such as accidents) of the CSAS should be carried out. This assessment is necessary to ensure that squadron Commanding Officers, and senior leadership, are being provided with valid and reliable information on squadron safety climate.

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I. INTRODUCTION

The purpose of this literature review is to provide the background to an evaluation of the utility of the Command Safety Assessment Survey (CSAS) as a valid predictor of future mishaps. The end goal is to be able to use the survey to identify “at risk” U.S. Naval squadrons prior to the occurrence of mishaps. The CSAS was designed to measure the safety climate of U.S. Naval aviation squadrons. In this literature review, safety climate will be defined and the method of measurement outlined. The literature concerning the correlation of safety climate with other indicators of safety performance will be discussed. Finally, the research on safety climate that has been carried out in aviation will be delineated, with a specific emphasis on the method used to assess the safety climate in U.S. military aviation.

The military operates in a high-risk environment, utilizing highly complex technologies to achieve mission goals. The reliability of the hardware and software of these complex systems has been steadily improving, resulting in dramatic decreases in the number of failures over the last century (O’Connor & Cohen, 2010). To illustrate, in U.S Naval aviation, 776 aircraft were destroyed due to accidents in 1954, compared to only 24 in 2000 (Wiegmann & Shappell, 2003). However, although the absolute mishap rate has decreased, the proportion of mishaps attributed to human error has not decreased at the same rate as the mishaps involving mechanical and environmental factors (Wiegmann & Shappell, 2003). In U.S. Naval aviation, human error accounts for more than 80% of mishaps (Naval Safety Center, 2006). This finding is not unique to U.S. Naval aviation, as between 80% and 90% of all work-related accidents and incidents can be attributed to human error (Health and Safety Executive, 2002; Hollnagel, 1993; Reason, 1990). Therefore, as has been the case with other High Reliability Organizations (HROs; those organizations which are operating technology that is sufficiently complex to be subject to catastrophic accidents; Shrivastava, 1986), the United States military has recognized the need to focus upon the human causes of mishaps.

Traditionally, safety performance has been assessed solely on the basis of “lagging indicators” of safety such as fatalities, or mishap rates. However, as safety has improved and the frequency of mishaps has declined, mishap rates have ceased to be a useful metric of safety performance. Therefore, HROs have started to examine “leading indicators” of safety. The

United Kingdom Health and Safety Executive (HSE, 2006) defined leading indicators of safety as measures of process or inputs essential to deliver the desired safety outcomes (e.g., safety climate surveys, hazard reports). Lagging indicators show when a desired safety outcome has failed or has not been achieved (e.g., number of mishaps). Therefore, leading indicators of safety are used in an attempt to gain insight into the safety performance of the organization and identify areas in which efforts should be made to improve safety.

A. DEFINITIONS OF SAFETY CULTURE AND SAFETY CLIMATE

Zohar (1980) defined safety climate as a summary of perceptions that employees share about their work environment. Safety climate describes employees' perceptions, attitudes, and beliefs about risk and safety (Mearns & Flin, 1999). It is a "snapshot" of the current state of safety in the organization. There has been an ongoing debate within the literature regarding the use of the terms "culture" and "climate," and whether they represent the same or different concepts. The general consensus is that culture represents the more stable and enduring characteristics of the organization, and has been likened to its traits or "personality." Safety culture is a more complex and enduring trait, reflecting fundamental values, norms, assumptions, and expectations, which, to some extent, reside in societal culture (Mearns & Flin, 1999). Climate, on the other hand, is thought to represent a more visible manifestation of the culture, which can be seen as its "mood state," at a particular moment in time (Cox & Flin, 1998).

Denison (1996) argues that the methods used by researchers can help to distinguish between culture and climate studies. He argues that culture requires qualitative measures, while climate requires quantitative measures. Because the questionnaire survey is the predominant method used for investigating safety, it is now widely recognized that this method reflects the climate of the organization at the time of the study (Denison, 1996). However, it is generally agreed that climate can be used as an indication of the underlying safety culture (Cox & Cheyne, 2000; Mearns & Flin, 1999). The point is put succinctly by Rousseau (1985), who states that the similarities between the concepts of climate and culture are sufficiently overlapping for research on one to inform us about the other. For the remainder of this literature review, we focus on safety climate.

B. MEASURING SAFETY CLIMATE

As discussed above, safety climate is almost predominately measured using a questionnaire methodology. Guldenmund (2007) describes this method as a quick, but also "dirty" technique for measuring safety climate. It is dirty because it arguably only gives a little insight into the safety climate of the organization from a single perspective. Guldenmund (2007) states that "the challenge is to develop a questionnaire that yields just enough relevant information—the trusted 'wet finger' to find out which way the wind blows—to decide whether and possibly where any corrective measures or actions are opportune" (p. 724).

Unlike the field of personality assessment, in which consensus has been largely reached regarding personality constructs, there has been no such agreement regarding safety climate constructs. It is debatable whether safety climate instruments should be generic or specific in nature (Cox & Flin, 1998). Cheyne, Tomas, Cox, and Oliver (1999) argued that the architecture of employee attitudes to safety was context-dependent and varied by industrial sector. Likewise, Coyle, Sleeman, and Adams (1995) found different factor structures, using the same safety climate scale, in two Australian health care organisations, concluding that the likelihood of establishing a universal and stable set of safety climate factors was highly doubtful. Zohar (2003) concurs, arguing that safety climate indicators should be subdivided into universal and industry-specific indicators.

Over 40 different safety climate measures have been developed (Yule, O'Connor, & Flin, 2003). These questionnaires tend to be self-administered, and can be delivered to a large number of people in an organization relatively easily. The first stage in developing a safety climate questionnaire is to identify a number of thematic items that are thought to be relevant to the safety climate. Guldenmund (2007) differentiates between two methods for identifying the items: a normative, or theoretical, approach in which the items are derived on the basis of a theoretical model of safety climate, or a pragmatic approach in which the questionnaire builds upon previous research. Responses to each item are generally assessed using a Likert scale. For analytic purposes, these scales are generally considered to be interval (although they almost certainly are not), so that multivariate statistical methods can be used.

The items are designed to assess a particular safety climate theme (e.g., safety systems). The purpose is to develop a number of scales that can be used to evaluate whether there are

differences between groups of respondents on particular aspects of the safety climate. Using scales, as opposed to examining the responses to single items, allows the researcher to have a greater reliability in the participant's view of a particular aspect of the safety climate.

Once the data has been collected, exploratory factor analysis is used to identify whether the items are grouping (or loading) on the themes as anticipated. As part of this process, items are often discarded. Themes also may be deleted, combined, or renamed. This adaption to the questionnaire is a normal part of the factor analysis process. Once a stable factor structure has been established, attempts may then be made to confirm this structure with a different data set. The exploratory and/or confirmatory factor analyses are a necessary process in the construction of reliable scales. These techniques also help to establish the construct validity of the tool. Construct validity is concerned with the extent to which the questionnaire measures what it is intended to measure. Identification of a reliable factor structure, that is consistent with theory, helps the researcher substantiate claims regarding the validity of the questionnaire, although there is no consensus on the specific factors that comprise the safety climate. As seen in a number of reviews (e.g., Cohen, 1977; Flin, Mearns, O'Connor, & Bryden, 2000; Guldenmund, 2000; Hale & Hovden, 1998; Shannon, Mayr, & Haynes, 1997), there is some agreement regarding the themes that are relevant to the construct of safety climate. These common themes will be discussed in the next section.

C. COMMON SAFETY CLIMATE THEMES

Although there are a large number of factors that have been identified by safety climate researchers, these factors can be reduced to a limited number of themes (Gadd & Collins, 2002; Flin et al., 2000). To illustrate, in a review of 18 safety climate questionnaires, Flin et al., (2000) identified six common themes: management/supervision, safety systems, risk, work pressure, competence/training, and procedures/rules. Each of these themes will be discussed below.

1. Management/Supervision

A factor concerned with management is identified about 75% of the time in safety climate research (Gadd & Collins, 2002; Flin et al., 2000). However, this term is rather nebulous and refers to a wide range of managerial behaviors, from the development of the safety program to the quality of labor-management relations. Nonetheless, the research suggests that managers

can demonstrate their commitment to safety in a number of tangible ways—first, through their commitment to structural and procedural safety systems including the development of the safety program. This program includes a diverse range of activities such as: good housekeeping and environmental conditions, good training facilities, clear safety policy and goals, formal inspections at regular and frequent intervals, thorough investigations of all accidents and near misses, thorough record keeping, rules and regulations regularly updated and evidence of management and staff compliance with them, a high priority being given to safety at company meetings, an active safety committee and a high-ranking safety officer (Cohen, Smith, & Cohen, 1975; Smith, Cohen, Cohen, & Cleveland, 1978; Simons & Shafai-Sharai, 1977). Secondly, and perhaps more importantly, management can demonstrate their commitment to safety through their attitudes, behaviors, and styles of leadership. These factors tend to be less tangible than the structural and procedural variables, but nonetheless are thought to have at least as powerful an effect on workforce safety motivation (Eyssen-McKeown, Eakin, Hoffmann, & Spengler, 1980; Andriessen, 1978; Zohar, 1980, 2000). In fact, Hale and Hovden (1998) suggest that structural factors are likely to be critical only in organizations with a poor safety climate; they cease to discriminate once the company has achieved a modest level of advancement in safety management. It is the other less tangible factors concerning management's attitudes and style of leadership, as well as the nature and quality of interactions with the workforce, which are better at discriminating the excellent from the good organizations.

The importance of interactions between managers and workers has been clearly established through the research (Andriessen, 1978; Hale & Hovden, 1998). Specifically, management participation and involvement in work and safety activities, as well as frequent, informal communications between workers and management, are recognized as critical behaviors. These interactions serve a number of useful functions: they demonstrate the managers' concern for safety; serve as a frame of reference for the workforce to guide appropriate task behaviors; foster closer ties between managers, supervisors, and workers; encourage a free exchange of ideas on job improvement; and provide an opportunity for the early recognition of hazards and improper job practices (Cohen, 1977). More importantly, worker-management interaction provides a clear indication of an overt, active, and genuine concern for safety on the part of management. The evidence strongly supports the utility of

management demonstrating the priority for safety over production goals (Eyessen-McKeown et al., 1980; Diaz & Cabrera, 1997). Interestingly, those organizations that have clear safety goals also tend to be more productive (Peters, 1989).

A decentralized approach to safety management has been shown to be the most effective way in which management can promote workforce safety motivation (Griffin, Burley, & Neal, 2000; Simard & Marchand, 1995). This approach is achieved by encouraging the joint involvement of supervisors with employees in relatively structured safety activities. Indeed, decentralized management at all levels is not only the best predictor of workgroups' propensity to safety initiatives; it also is the most important factor in relation to two other predictors of worker motivation to safety, namely workgroup cooperation and cohesion (Simard & Marchand, 1995). Cooperative relationships are characterized by a positive team spirit and willingness to cooperate with other team members, and other teams, in order to achieve the organization's goals. Workgroups, which are internally cohesive and cooperative, also tend to be more cooperative with management (Griffin et al., 2000). Thus, any attempt by senior management to increase workers' safety motivation must begin by attempting to increase supervisors' and workers' capacity to behave cooperatively with each other, thereby meeting their social and autonomous needs.

A number of supervisory-level variables also have been identified as being associated with good safety performance. Specifically, participative and supportive supervisory behavior is identified as critical to safe performance (Niskanen, 1994; Flin, Mearns, Gordon, & Fleming, 1996). These supervisory behaviors are strongly promoted when the supervisors are allowed autonomy within their own jobs. Numerous studies suggest that a decentralized approach on the part of more senior management is conducive to more participative relationships further down the line (Hofmann & Morgeson, 1999).

The empirical evidence suggests that it is not just management commitment, participation, and involvement in safety activities that are important, but the extent to which management encourages the involvement of the workforce. In particular, the workforce must be permitted to help shape interventions rather than simply be passive recipients. In this way, workers are more likely to take ownership and responsibility for safety and to become actively motivated to take personal initiative in safety (Niskanen, 1994; Williamson, Feyer, Cairns, &

Biancotti, 1997). Cohen and Cleveland (1983) make the following observations based upon their three-phased study: people work more safely when they are involved in decision-making processes; when they have specific and reasonable responsibilities; authority and goals; and when they have immediate feedback about their job performance.

2. Safety Systems

This very broad theme has a number of overlapping dimensions to it, including: the condition of physical plant and equipment; safety systems such as Permit to Work (PTW) systems, hazard identification systems, and including incident reporting systems; accident investigation and record keeping; safety rules, policies, and procedures; selection promotion and training; safety department effectiveness; and communication and feedback mechanisms (Flin et al., 2000). A factor related to safety systems is identified in about two-thirds of safety climate studies (Gadd & Collins, 2002; Flin et al., 2000).

Perception of the safety systems is clearly an important component of safety climate. For example, in a safety climate study of offshore oil company workers, Mearns, Flin, Gordon, and Fleming (1998) found that reporting systems, rules and procedures, and safety systems were among the key factors related to self-reported accident involvement. Similarly, in an investigation of safety practices among a telephone company's construction and maintenance workers, Eyssen-McKeown et al. (1980) found that lower injury rates were associated with the perceived effectiveness of safety regulations and the safety program.

Furthermore, the evidence suggests that perceptions of leadership commitment to safety appear to influence opinions about the safety system, which in turn appear to influence employees' at-risk behaviors and injury rates (Simard & Marchand, 1994, 1995, 1997). A comparison of high and low accident companies has shown that in high-performing companies, safety policy and procedures were characterized by clarity, consistency, and emphasis (Gaertner, Newman, Perry, Fisher, & Whitehead, 1987).

Unfortunately, because data related to safety systems are often available from other more traditional methods such as safety audits and hazard reports, issues related to the safety system are often omitted from climate scales. Bailey and Petersen (1989) concluded that the effectiveness of safety programs cannot be measured by the more traditional procedural-engineering criteria popularly thought to be factors in successful programs. They argue that a

better measure of safety program effectiveness is the response from the entire organization to questions about the quality of the management systems that have an effect on human behavior relating to safety.

3. Training and Competency

The workforce's perception of the general level of workers' qualifications, skills, and knowledge is the essence of this theme. Training is a key component, both directly through its effect on workers' competency to perform their work functions, but also indirectly through influencing perceptions about management's commitment to safe and reliable work systems. In fact, Cooper and Phillips (2004) demonstrated that workers' perceptions of the significance of safety training were the most important safety climate factor predicting actual safety behavior.

In recent years, many high-reliability organizations have embarked upon a process of multiskilling the workforce. This process can be seen positively or negatively by the workforce, depending upon whether it is properly applied and resourced. Concurrent with this development, HROs have also emphasized competence in nontechnical skills (e.g., leadership and decision making) that are regarded as contributing factors to safe operations (Helmreich & Merritt, 1998). These are usually taught in crew resource management training programs (Flin, O'Connor, & Crichton, 2008) and, as such training becomes more widespread, this aspect of the skill base also may need to be incorporated into a competence factor.

4. Risk

The risk literature focuses on three aspects of risk:

- risk perception – the extent to which a person believes a particular activity or situation is risky;
- risk tolerance – the extent to which a person is willing to engage in risky behaviors; and
- risk behavior – the frequency with which a person engages in risky activities or situations (Kivmaki, Kalimo, & Salminen, 1995; Dedobbeleer & Beland, 1991).

In the aviation industry, pilots who reported higher risk perception also reported lower risk tolerance towards experiencing risky aviation activities, particularly for weather-related situations (Hunter, 2002). Importantly, the number of experienced hazardous events was

consistent with self-reported risk tolerance (e.g., those pilots who rated various aviation activities as more risky than the average pilot experienced fewer hazardous events [Hunter, 2002]). Additionally, risk tolerance was a significant factor in a model attempting to distinguish between pilots who had experienced an accident and those who had not (Platenius & Wilde, 1989). Pilots involved in an accident were more likely to endorse statements such as “I fly in spite of advice from others,” “if a pilot doesn’t take occasional risks, they won’t learn to get out of emergencies,” and “physically capable people can take more risks.”

Studies of risk perception in other industries have shown that workers have fairly accurate perceptions of the risks they face (Flin et al., 1996). Moreover, just as in the aviation environment, higher threat perception is positively related to safe behaviors. For example, Goldberg, Dar-El, and Rubin (1991) found that a high threat perception was related to readiness to participate in safety programs, the relationship was mediated by coworker support for safety. Workers who sensed high coworker support for safety were more likely to be positively oriented towards greater participation. Cheyne, Cox, Oliver, and Tomas (1998) found that perception of workplace hazards did not have a direct effect on levels of safety activity by the workforce. However, an indirect effect was found, such that higher appraisals of workplace hazards were related to more positive perceptions of individual responsibility, which, in turn, affects levels of safety activity. Similarly, Dedobbeleer and Beland (1991) speculate that workers’ perceptions of risk and control may be highly related to workers’ involvement and responsibility for safety. Overall then, it seems that risk perceptions and safety behaviors are positively related to perceptions of involvement.

In a study of U.S. coal mines, the opposite effect also appears to hold true. Brown, Willis and Prussia (2000) found that safety hazards directly caused accidents and indirectly influenced employees’ perceptions of the safety climate. Higher perceptions of hazard are associated with reduced perceptions of manager and supervisor attitudes towards safety. Higher perceptions of risk are also associated with increased production pressure, which leads to unsafe behaviors.

5. Work Pressure

Factors relating to work pace, workload and work pressure, and production pressure are common in safety climate surveys, and for good reason. This factor has consistently shown a positive relationship with accident rates. For example, Cooper and Phillips (2004) found

significant differences in perceptions of work pace between accident-involved and non-accident-involved workers. Diaz and Cabrera (1997) found that employees' perceptions of the organization's philosophy of either production or safety, was the second most important factor (after organizational policies towards safety) in predicting safety performance. Pfeifer, Stefanski, and Grerther (1976) questionnaire results indicate that supervisors in low-accident rate mines were significantly less inclined to push hard for production or to cut corners on safety. Sanders, Patterson, and Peay (1976) found that increased levels of production pressure were associated with increased lost time injury rates.

In his sociological investigations into the causes of accidents in the U.K.'s offshore oil industry, Wright (1986) found that perceptions of performance pressure can lead workers to believe that engaging in short-cut behavior is an expected or required part of the job. Workers who perceive a high degree of performance pressure will focus their attention on completing the work and focus less on the safety of their work procedures.

6. Procedures/Rules

Guldenmund (2000) identified procedural and rule compliance as one of the most frequently occurring themes in his review of safety climate research. Perceptions of safety rules, attitudes to rules and compliance, and violation of procedures are addressed. This theme is also related to risk-taking behaviors, as these can involve rule breaking. Some of these factors have been shown to relate to accident involvement in safety climate surveys (e.g., Lee, 1998), but causal relationships remain more obscure and are likely to be influenced by supervisory behavior and work pressure variables. This issue has received scrutiny in studies of worksite safety (Reason, 1998), suggesting that procedural compliance is an issue that should be addressed in measures of safety climate.

Like many of the other safety climate themes, procedural and rule compliance appears to be strongly influenced by perceptions of management and labor-management relations. For example, Thompson, Hilton, and Witt (1998) found that the supervisor's role in promoting workplace safety is achieved by affecting the perceived level of fairness in their organization's climate, which, in turn, impacts on workforce compliance with safety rules. Likewise, Simard and Marchand (1997) found that a cohesive and cooperative workgroup relationship is by far the most important variable in terms of predicting workgroups' propensity to comply with safety

rules. Cooperative relationships are characterized by more open communications and positive team spirit.

Overall, the studies reviewed reveal a number of interesting findings relating to the nature of workforce motivation and the changing roles of managers, supervisors, and workers. It seems that employees are now expected to do more than just comply with rules and regulations. They are expected to act proactively, be personally committed to safety, take responsibility and ownership for safety, and be committed to corporate safety goals.

To summarize, the six themes reviewed above represent those that are most commonly included in measures of safety climate. It also can be seen that the literature supports the notion that these themes should be considered when assessing the safety climate of an organization. Thus, a measure of safety climate should include items that address each of these themes. In the next section, the evidence linking safety climate to other measures of safety performance will be discussed.

D. CORRELATING SAFETY CLIMATE WITH OTHER MEASURES OF SAFETY PERFORMANCE

In addition to establishing the construct validity of a safety climate questionnaire, it is also necessary to determine the discriminate validity. If the tool is insufficiently sensitive in its ability to differentiate between organizations or personnel with different levels of safety performance, then the tool is of limited usefulness. The discriminate validity can be assessed by correlating the data from the questionnaire with a criterion variable such as accidents, or other safety-related behavior (Guldenmund, 2007).

In recent years, a large number of research studies have been conducted that have sought to examine the contribution of safety climate to accidents. The challenge facing researchers has been to highlight measurable dimensions of safety climate that can be used to identify, in advance, the strengths and weaknesses within an organization that influence the likelihood of accidents occurring. A variety of different criteria are used upon which to base evaluations of organizational effectiveness in preventing accidents including: company accident statistics; comparison of high and low accident rate plants, and evaluation of plants with outstanding safety records; and self-reported safety behaviors and safety attitudes.

1. Company Accident Statistics

Over the past two decades, researchers have demonstrated relationships between a variety of safety climate factors and accident rates across a range of high-risk industries. Such studies have shown that the degree of safety program development and workers' safety initiative were related to lower work accident and injury rates (Simard & Marchand, 1994; Zohar, 2000; Dwyer & Raftery, 1991; Donald & Canter, 1994; Mearns, Rundmo, Flin, Gordon, & Fleming, 2004).

Johnson (2007) provides support for safety climate as a viable construct and as a predictive indicator of safety-related outcomes. This study used the responses of 292 employees at three locations of a heavy manufacturing organization to complete the 16-item Zohar Safety Climate Questionnaire (ZSCQ; Zohar & Luria, 2005). In addition, safety behavior and accident experience data were collected for five months following the survey and were analyzed to identify correlations, associations, internal consistency, and factorial structures. Results revealed that safety climate, as measured by the ZSCQ, served as an effective predictor of safety-related outcomes (behavior and accident experience).

There are problems with using accident rates because they are a notoriously unreliable measure of an organization's true safety performance. Used alone, they can be a misleading indicator of the effectiveness of a safety program (Thompson et al., 1998). Four main difficulties have been identified:

1. restriction of variance: accidents are rare occurrences, which can make the data unreliable;
2. random events that are not under the direct control of personnel can sometimes intercede to cause accidents, which also produces unreliability;
3. accidents may not be consistently recorded across organizations, and over and under recording causes unreliability; and
4. the measurement of accident severity is often a highly subjective issue and, therefore, also causes unreliability (Thompson et al., 1998; Witt, Hellman, & Hilton, 1994; Zohar, 1980). For these reasons, many researchers have abandoned the use of accident frequency data and accident severity rates as a measure of safety effectiveness, in favor of measures such as self-reported accident involvement (see later for a discussion).

2. Comparison of High and Low Accident Rate Plants

Other studies have compared high- and low-accident-rate plants (or evaluated plants with outstanding safety records) as their criteria upon which to base judgments of effectiveness. However, it is difficult to identify those variables that are *crucial* to their outstanding performance, as opposed to those that are simply associated with it. The differences highlighted between good and bad companies may only be a fraction of the total and these differences may change over time (Mearns, Flin, & O'Connor, 2001). Furthermore, the causal relationship between variables and outcomes are not proven, it is often difficult to say which is the independent variable and which the dependent variable (Hale & Hovden, 1998). Nonetheless, the early studies that compared high- and low-accident-rate organizations did identify issues that have been supported by the other more objective approaches to validation.

As with much of the other literature on safety culture and climate, in studies that compare high- and low-accident-rate plants, management emerges as a key and consistent determinant of safety performance. In particular, management's commitment to safety was found to be greater in low-accident-rate plants than in the high-accident-rate plants (Cohen, Smith, & Cohen, 1975; Smith et al., 1978; Cohen & Cleveland, 1983). Commitment is expressed through the allocation of resources to safety and health, and more active involvement and participation by management in safety program matters (Cohen & Cleveland, 1983; Diaz & Cabrera, 1997). Aside from their commitment, a manager's style of leadership (centralized or decentralized), a manager's involvement with workers, and labor-management relations appear to be the key factors that distinguish the high from the low performers (Braithwait, 1985; DeMichiei, Langton, Bullock, & Wiles, 1982).

High levels of management control over work organization and task structure, serves to reduce worker autonomy and worker integration, which is associated with higher accident rates (Dwyer & Raftery, 1991; Braithwait, 1985; Sanders et al., 1976). Worker involvement in decision making and policy setting serves to reverse this trend. Cohen and Cleveland (1983), in their analysis of the top-performing companies, found that in the best companies in the USA, workers were more involved in the decision-making process. They had a direct channel to communicate their thoughts and ideas to management; management was more receptive and

responsive to requests and suggestions; and more frequently solicited input concerning policies and procedures from workers.

Conversely, poor labor management relations are associated with significantly higher self-reported violation rates and higher injury rates (Gaertner et al., 1987). Direct channels of communication between labor and management appear to be an important factor. Smith et al. (1978) found that management of low-accident-rate plants seemed to have a greater level of one-to-one interaction with their employees, while in high-accident-rate plants, management more often relied upon committees to interact with employees. Similar findings are reported by Cohen and Cleveland (1983), who found that the top-performing companies provided direct and immediate channels of communication and positive employee-management interactions.

3. Self-Reported Safety Behavior

Self-reported safety behavior and safety attitudes are an alternative to relying on mishaps data to evaluate the effectiveness of an organization's safety program. Thompson et al. (1998) suggested that minor workplace accidents often go unreported, yet these events may be the best indicators of improving (or worsening) safety conditions that might eventually lead to serious injury. Members of the workforce are likely to be sensitive to the type and frequency of accidents that go under-reported and, as such, their sense of workplace safety conditions might be a better indicator of safety risk than the routine accident reports (Thompson et al., 1998). However, this approach is complicated by questions about who is in the best position to provide the ratings. Some studies use supervisory or managerial attitudes towards employees' safety behavior (Simard & Marchand, 1994; 1995; 1997), others use employees' ratings of their own attitudes and those of their managers and supervisors. (Andriessen, 1978; Thompson et al., 1998). However, the judgments are likely to be influenced by attribution bias (i.e., attribute poor performance to other people rather than one's self). Employees may have little direct evidence of management attitudes to safety; rather, they may infer managerial attitudes on the basis of their experiences of supervision. Similarly, management who are removed from operations may have little direct experience of employee opinions (Clarke, 1999). In most of the studies published in the literature, no explanation is given for the choice of respondent used. It seems that methodological convenience, as much as theoretical reasoning, is driving the decision.

Climate is linked to safety outcomes through behavior-outcome expectancies. These expectancies guide behavior through learning. Evidence has shown that safety behaviors are positively related to company safety records, and reduced accident and injury rates. Cooper and Phillips (2004) established an empirical link between a limited set of safety climate perceptions and actual safety behavior. They also demonstrated that changes in climate perceptions do not necessarily reflect changes in levels of behavioral safety performance. Equally, changes in safety behavior are not necessarily reflected in safety climate perceptions. Such results remind us that it is reductions in the frequency of unsafe behaviors and their antecedents (i.e., unsafe conditions or situations) that reduce the opportunity for accidents to occur, not perceptions about how safety is operationalized. The findings strongly suggests that industry should focus its primary safety improvement effort on changing unsafe situations and conditions, as well as people's safety behavior at all organizational levels, rather than concentrating on improving people's attitudes, beliefs, and perceptions about safety. The authors argue for the use of a variety of safety performance outcome variables, rather than relying primarily on self-report instruments.

More recently, a number of meta-analytic studies have been conducted in order to evaluate the relationship between safety climate as a holistic construct and accident rates. Clarke (2006) used a meta-analysis to examine the validity of the relationship between safety climate and safety performance and occupational accidents and injuries (r=0.2). The study found support for the link between organizational safety climate and employee safety participation; however, the links to accident involvement were found to be weak. Not surprisingly, the relationship between safety climate and accident involvement was moderated by the study design, such that only prospective design, (i.e., studies in which accidents were measured following the measurement of safety climate) demonstrated validity generalization. Those studies that were retrospective (i.e., studies where the measurement of accidents or injuries is taken before the measurement of safety climate) did not show such a link. This finding holds with the principle that climate predicts accidents and not the other way around.

Similarly, Nahrgang, Morgeson, and Hofmann (2007) conducted a meta-analysis that examined the relationship between safety performance and its antecedents—including safety climate—in order to establish which factors are more influential in establishing strong safety performance (accident and injury rates, and positive safety behavior). Results indicate safety-

related antecedents (such as risks and hazards, safety prevention, and safety involvement) and general antecedents (leadership and commitment) have moderate to strong relationships with safety climate. Leadership and safety climate both demonstrate moderately negative relationships to accidents and injuries, and moderately positive relationships with positive safety behavior. However, risks and hazards is the only safety-related antecedent, which correlates with accidents and injuries. Leadership also demonstrates moderate relationships with the two safety outcomes of accidents and injuries and positive safety behavior. Overall, safety climate negatively correlates with accidents and injuries.

The studies suggest that the behaviors that underlie safety culture are even more critical as indicators of an organization's safety performance than other, more traditional, measures such as accident or incident rates. Herein lies the greatest strength of the concept. Safety climate introduces the notion that the likelihood of accidents occurring can be predicted on the basis of certain organizational factors. These organizational factors can be used as leading indicators to identify, in advance, the strengths and weaknesses within an organization that influence the likelihood of accidents occurring. Once weaknesses are identified, remedial actions can be taken (Flin et al., 2000).

To summarize, as would be hoped, there would appear to be a link between safety climate and mishaps. However, the relationship is not as strong as may be expected, part of which can be attributed to the difficulties in obtaining accurate and truthful mishap data. In the next section, the safety climate research that has been carried out in aviation will be delineated, with particular emphasis on the tools used by U.S. Naval aviation.

E. SAFETY CLIMATE ASSESSMENT IN AVIATION

Wiegmann and colleagues (Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004) report that "few formally documented efforts have been made to assess safety culture within the aviation industry, with the notable exception of military aviation" (p. 117). This finding is surprising, given that the civilian aviation industry has led other high reliability in developing and utilizing a number of human-focused safety programs (e.g., crew resource management). However, the extent to which safety climate surveys are being used in commercial aviation is difficult to assess. It is recognized that there are undoubtedly many aviation consultancy companies carrying out safety climate assessments. However, because this information is not in

the public domain, this work cannot be reviewed. Below is a discussion of 10 studies carried out in commercial aviation that report a safety climate evaluation, and are available in the public domain.

1. Commercial Pilots

The Australian Transportation Safety Board (2004) and Evans, Glendon, and Creed (2007) both reported on a study examining the safety climate of Australian pilots. The questionnaire consisted of six safety factors (management commitment, training, equipment and maintenance, rules and procedures, communication, and schedules), each with five items. These factors were based upon previous safety climate research and input from aviation safety experts. Data from half of the sample were used in an exploratory factor analysis that resulted in a three factor model of: management commitment and communication, safety training and equipment, and maintenance. A confirmatory factor analysis on the remaining half of the sample showed the three factor model to be an adequate fit to the data. Finally, the responses from different types of pilots (regular public transport, charter, or aerial work such as emergency medical services or agriculture) were compared on each of the four identified safety climate factors. No significant differences between the groups were found. The Australian Transportation Safety Board (2004) concluded that this was due to a single professional safety climate for pilots as a group, regardless of the organization for whom they worked.

Gibbons, von Thaden, and Wiegmann (2006) developed a questionnaire designed to assess safety culture within the context of airline flight operations. The survey consisted of 84 items, grouped into five themes (organizational commitment, management involvement, employee empowerment, reward systems, and reporting systems). The survey was designed by examining the content of safety climate questionnaires that have been used in other HROs. A total of 503 responses were received from a single company. After discarding 29 items and using a confirmatory factor analysis technique, the analysis eventually resulted in structure of four broad factors (organizational commitment, operations personnel, informal safety system, and formal safety system), with three subfactors in each. The authors attribute the difficulty in establishing a stable factor structure with the analysis to issues in item writing (e.g., ambiguity, items that did not relate well to the target population). Another issue not mentioned in the paper

is the relatively low ratio of items to responses. No analysis of the revised questionnaire was reported.

2. Cabin Staff

Kao, Stewart, and Lee (2009) developed a 23-item questionnaire to assess the safety climate attitudes of Taiwanese cabin crews. The questionnaire was designed to assess the following safety climate themes: management commitment towards safety, cabin work environment, rule compliance, crewmember involvement and participation, accident investigation, and injury incidence. The items were based upon previous safety climate research. A total of 331 responses were obtained from cabin crews from four major Taiwanese airlines. Using a structural equation modeling approach, the researchers found an acceptable level of fit with the proposed factors. High management commitment to safety was significantly related to high crewmember participation in safety, and that safe cabin work environment was significantly related to crewmember’s individual behavior. However, the findings did not reveal a direct relationship between management commitment and injury incidence.

3. Ground Handlers

Diaz and Cabrera (1997) developed a 40-item safety climate questionnaire for aviation ground handlers, based upon the work of Zohar (1980). Following a PCA on the data collected from 166 ground handling personnel at a Spanish airport, six factors were identified: company policy towards safety, emphasis on productivity versus safety, group attitudes to safety, specific strategies of prevention, safety level perceived in the airport, and safety level perceived on the job. It was found that the questionnaire was able to discriminate between organizations with different levels of safety.

Ek and Akselsson (2007) evaluated the safety culture in the ramp division of a ground handling company. A 109-item questionnaire was developed that addressed nine aspects of safety climate: working situation, communication, learning, reporting, justness, flexibility, attitudes towards safety, safety-related behaviors, and risk perception. Data were collected from 50 men employed by a single ground handling company. Acceptable levels of internal consistency were found for each factor. They concluded that the safety climate was good, but poorer than desired by managers.

4. Aviation Maintainers

As part of a larger research project, McDonald, Corrigan, Daly, and Cromie (2000) designed and utilized a safety climate questionnaire to survey aviation maintainers. The questionnaire was adapted from the one developed by Diaz and Cabrera (1997; described above). A 36-item questionnaire was designed based upon a factor analysis of 69 items (this analysis was not reported). A total of 622 responses were obtained from aviation maintainers from four companies. Significant differences in climate were found between different occupational groups. McDonald et al. (2000) reported that the data provided evidence of a strong professional subculture, which spanned all of the four companies that participated in the study. Further, this subculture is relatively independent of the organization. It was postulated that the subculture is likely to mediate between the organization's safety management system and safety outcome.

5. Air Traffic Controllers

Gordon, Kirwan, Mearns, Kennedy and Jensen (2007) describe a pilot study of a climate survey designed for use by European air traffic controllers (ATC). The questionnaire consisted of 59 items of 13 elements designed around three themes (priority of safety, involvement of safety, and learning from safety). The items were selected based upon a literature review, 50 interviews with ATC personnel, and input from subject matter experts on the final items to be included. The questionnaire was piloted with 119 responses obtained. Following an exploratory factor analysis, an 8-factor questionnaire resulted (see Table 1 for a description of the factors). Gordon et al. (2007) acknowledge that the sample was small, and they state that a larger validation study will be carried out.

6. Combined Commercial Aviation

Patankar (2003) evaluated the safety climate of a stratified sample of 399 personnel (flight operations, maintenance, and other personnel) from a single aviation company using a common safety climate questionnaire. The questionnaire was based upon the cockpit management attitude questionnaire, (CMAQ; Gregorich, Helmreich, & Wilhelm, 1990), the maintenance resource management/technical operations questionnaire (MRM/TOQ; Taylor, 2000), and the CSAS (discussed in detail below). After a factor analysis (no details of this were reported), eight factors emerged: pride in company, professionalism, safety opinions, supervisor

trust and safety, effects of my stress, need to speak up, safety compliance, and hazard communication. Significant differences were found between flight operations, maintenance, and "other" personnel with regard to the factors of pride in company, safety opinions, and supervisor trust. Patankar (2003) concluded that, overall, the respondents were proud to work for the company, trusted management, and believed that safety is a result of collective efforts. It also was commented on that both flight and maintenance personnel had a high sense of personal responsibility for flight safety.

In a later study, the data collected by Patankar (2003; called company A) was compared to 237 responses collected at another company (called company B; Kelly & Patankar, 2004). It was found that, overall, there was a more positive safety climate at company A than company B. However, this finding was partially attributed to company A having older and more experienced pilots and mechanics than company B.

Block, Sabin, and Patanakar (2007) reanalyzed the responses obtained from the 281 pilots from the Patanakar (2003) sample. The purpose was to examine whether the data supported what Block et al. (2007) described as the purpose-alignment-control (PAC) model. A pair of experts recoded the Patankar (2003) survey items in accordance with the PAC model. The proposed factors were tested using a structural equation modeling methodology. The main drivers of safety outcomes were organizational affiliation (similar to pride in company from Patankar, 2003) and proactive management (partially derived from safety opinion factor from Patankar, 2003). Organizational affiliation was directly influenced by communication, and proactive management was influenced by training effectiveness and relational supervision.

Gill and Shergill (2004) conducted a safety climate review across the New Zealand commercial aviation industry. The safety climate questionnaire they developed included questions designed to address two themes: organizations' approach to safety management (26 items) and "safety management systems, and safety culture in organizations" (26 items). A factor analysis of 464 responses was run independently on each theme. The "safety management systems" theme was found to consist of four factors: positive safety practices; safety education; implementation of safety policies and procedures; and individual's safety responsibilities. The "safety culture in organizations" theme was also found to consist of four subfactors: organizational dynamics and positive safety practices; regulator's role; luck and safety; and

safety management, training, and decision making. The main findings from the study were that pilots believed luck and safety to be the most important factor in aviation safety, and employers were not perceived to be placing much importance on safety management systems and safety culture.

As can be seen from the review of the safety climate literature described earlier, a summarization of the research carried out in commercial aviation indicates that the themes are not dissimilar from those identified in nonaviation HRO safety climate research. The commercial aviation studies reviewed generally describe the development of "new" research questionnaires that, in most cases, have only been used once with a maximum of a few hundred respondents, and represent a one-time safety climate assessment. Furthermore, no attempts were made to examine the discriminate validity of the measures by correlating the survey data with other safety performance measures (e.g., accident rate). In contrast, U.S Naval aviation has been collecting data on safety climate continuously since 2000. The tools used to assess safety climate in Naval aviation will be discussed in the next section.

F. SAFETY CULTURE ASSESSMENT IN NAVAL AVIATION

The U.S. Navy utilizes two different tools to assess safety climate in aviation. The CSAS is used to obtain feedback from aviators, and the Maintenance Climate Assessment Survey (MCAS) to obtain information from aviation maintainers. It should also be mentioned that, although not discussed in detail here, the Navy also conducts safety climate workshops with aviation squadrons. The facilitators (specially trained senior naval aviators) conduct observations, interviews, and focus groups with squadron personnel. The purpose is to identify potential hazards that may interfere with mission accomplishment (see O'Connor & O'Dea, 2007, for more details). However, this program is run independently of the safety climate survey.

The safety culture questionnaires were developed by researchers at the Naval Postgraduate School in Monterey, California (Desai, Roberts, & Ciavarelli, 2006). Both questionnaires are completed online, and responses are obtained for each item on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). In 2004, Vice Admiral Zortman declared the MCAS and CSAS mandatory for all squadrons to complete semiannually and within 30 days following a change of command (Zortman, 2004). The results of a squadron's survey are only

available to the Commanding Officer (CO). However, aggregated data is made available to all COs for comparison of their squadron's performance with their peers.

The theoretical background underpinning the questionnaires is based upon the work carried out by Roberts et al. on HROs (Desai et al., 2006). Libuser (1994) developed a theoretical Model of Organizational Safety Effectiveness (MOSE) that identified five major areas relevant to organizations in managing risk and developing a climate to reduce accidents. The five MOSE areas are:

- Process Auditing – a system of ongoing checks to monitor hazardous conditions (e.g., "My command conducts adequate reviews and updates of safety standards and operating procedures.").
- Reward System – expected social compensation or disciplinary action to reinforce or correct behavior (e.g., "Command leadership encourages reporting safety discrepancies without the fear of negative repercussions.").
- Quality Assurance – policies and procedures that promote high quality performance (e.g., "Quality standards in my command are clearly stated in formal publications and procedural guides.").
- Risk Management – how the organization perceives risk and takes corrective action (e.g., "My command takes the time to identify and assess risks associated with its flight operations.").
- Command and Control – policies, procedures, and communication processes used to mitigate risk (e.g., "Crew rest standards are enforced in my command.").

On the basis of observations and interviews with maintainers, the MCAS has an additional sixth MOSE called "communication/functional relationships." This theme is concerned with having an environment in which information is freely exchanged, quality assurance is seen as a positive influence, and maintenance workers are shielded from external pressures to complete a task (Harris, 2000). A description of the research that has been carried out using the MCAS data will be described first, followed by studies that have utilized the CSAS.

1. Maintenance Climate Assessment Survey (MCAS)

A considerable amount of work examining the psychometric properties of the MCAS was

carried out by Naval Postgraduate School Masters' students in the late 1990s and early 2000s. Given the similarities between the MCAS and CSAS, and the lack of published research on the CSAS (see below for a discussion), these theses will be briefly described.

The MCAS was developed by Baker (1998) directly from the CSAS. He carried out Principal Component Analysis (PCA) on 268 responses from the maintenance personnel of three reserve Naval squadrons. He found that 25 out of the 67 items loaded on a single principle component. However, as all of the six MOSEs were represented in this principle component, he concluded that there is no evidence against the theoretical underpinning of the questionnaire. As a result of the analysis, Baker (1998) proposed a revision of the questionnaire consisting of 35 items.

The next study, carried out by Oneto (1999), was a PCA of 439 responses collected from maintainers at eight reserve squadrons. Oneto used the revised survey recommended by Baker (1998). Again, Oneto (1999) found a single principle component that explained a third of the variance. As this principle component consisted of items from all of the MOSEs, he also concluded that the theoretical model was sound.

Goodrum (1999) assessed the 1,000 responses from a Naval Air Reserve Fleet Logistics Support Wing. Again, following PCA, the first principle component explained a third of the variance, with the six items that loaded the highest on this component from four of the six MOSEs.

Harris (2000) examined the responses of 977 maintainers at a Marine Air Wing. Similar to the earlier studies, Harris reported a single principle component that explained a third of the variance, with almost all of the items from the questionnaire loading on this principle component. Harris then used the six MOSE components to interpret the data, and found statistically significant differences between squadrons. However, he did not find a statistically significant relationship between safety climate and aircraft-maintenance-related incidents. Stanley (2000), using the same dataset as Harris (2000), examined the relationship between demographics and MCAS. He found that demographics had little utility in predicting the scores of a given unit.

Hernandez (2001) examined 2,180 maintainer responses from 30 Naval aviation units using the online and paper and pencil versions of the test. Similar to Harris (2000), she did not

find that demographic data correlated with the MCAS response. The results of a PCA of the data resulted in a single dominant principle component that explained approximately a third of the variance. Furthermore, almost all of the questionnaire items loaded on this principle component. Hernandez (2001) did not find a significant relationship between MCAS score and aircraft-maintenance-related incident rate, or a significant difference in responses based upon the method of completing the questionnaire.

Most recently, Brittingham (2006) examined the MCAS responses from 126,058 maintainers collected between 2000 and 2005. After completing a PCA, she found that, prior to rotation, one principle component accounted for approximately 50% of the variance. She states that after varimax rotation, a second principle component emerged. The first principle component consisted of items concerned with overall command attention to safety, and the second related to workload and the availability of appropriate resources. However, Brittingham (2006) interprets these findings very differently from the MCAS studies described earlier. As the six MOSE components were not identified as an individual factors part of the PCA process, Brittingham (2006) states that “the MCAS was found to be an inadequate tool with questionable validity for gauging maintenance safety climate” (p. 31).

It could be argued that both the interpretation of Brittingham (2006) and that of the earlier studies are flawed, due to the lack of a clear understanding of the methodology that was employed to identify the principle components. PCA is the method to use when the researcher is attempting to reduce a large number of variables to a smaller number of components (Stevens, 1996). PCA analyzes variance with the goal of extracting the maximum variance from a data set with a few orthogonal (i.e., uncorrelated) components (Tabachnick & Fidell, 1996). Since principle component scores are always uncorrelated by construction, unrotated PCA never accounts for correlations between the presumed factors underlying the observations. Furthermore principle components (or their coefficients) are never chosen with reference to a body of theory; they always arise automatically from the maximization of variance explained.

Another related issue, which may have accounted for the large proportion of items loading on a single principle component, is the large proportion of respondents responding positively to the items. To illustrate, Goodrum (1999) reported that all questions were answered positively, with a mean range of between 3.17 and 4.37 (on a 5-point scale). Hernandez (2001)

reported a mean range between 3.18 and 4.15 for the items. Therefore, it would appear that there is limited variability in the responses to the items. This creates problems when carrying out a PCA because if all of the items have a similar lack of variability, then the PCA will tend to identify one principle component with a large number of items.

The other problem with items with low variability is that they are not useful from a discriminatory perspective. For example, Brittingham (2006) reported that for item 7 "our command climate promotes safe maintenance," 89% of respondents agreed or strongly agreed, and only 6% disagreed or strongly disagreed. Therefore, this item is not useful in distinguishing between high- and low-performing groups because the majority of participants are in agreement. A more discriminatory item reported in the Brittingham (2006) study was item 27 "day/night checks have equal workloads and staffing is sufficient on each shift." Although it could be argued that this item is asking two separate questions at the same time, at least there is some variance in response, with 58% agreeing or strongly agreeing and 34% disagreeing or strongly disagreeing. Therefore, item 27 may be useful in discriminating between different groups. The danger of retaining a large number of nondiscriminating items when exploring differences between different groups of respondents is that the discriminating items can become "washed out" when they are averaged with nondiscriminating items. Therefore, the use of PCA with a large number of low variance items may account for finding a single factor on which the majority of MCAS items load.

2. The Command Safety Assessment Survey (CSAS)

Compared to the MCAS, there has been much less research published examining the CSAS. An unpublished manuscript of an exploratory factor analysis of 1,254 surveys resulted in a 34-item, 3-factor model (Sengupta, 2000). The 3-factor model was also found to be an acceptable fit to the data when a confirmatory factor analysis was carried out. No attempt was made to name the factors, nor was there any discussion of the results in the manuscript. In a second study, Adamshick (2007) analyzed the data of every Navy and Marine Corps Strike-Fighter aviator that completed the CSAS from 2001 until 2005 (2,943 responses). He carried out PCA independently for the items that make up each of the five theoretical factors of the CSAS. For all of the factors, except for quality assurance and reward systems (for Naval

aviators only), it was found that a two or more factors solution resulted in a better fit to the theoretically-derived factors than a single factor model.

Given the failure of both of these studies to establish a factor structure that is consistent with the MOSE, the construct validity of the questionnaire arguably is in doubt. Further, the original work to establish the factor structure was carried out a decade ago. The safety climate of Naval aviation has not remained stagnant during this period. A number of safety programs have matured and become more widely utilized (e.g., crew resource management, operational risk management, human factors councils/boards; see O'Connor & O'Dea, 2007 for more details). Therefore, there is a need to reexamine the factor structure and assess the construct validity of the CSAS.

In fact, although the CSAS was used unaltered from 2000 until 2009, the content of the questionnaire had changed recently. The MOSE framework model was abandoned in favor of a framework that is loosely based upon the organizational influence and supervisor levels of the Human Factors Analysis and Classification System (HFACS; Wiegmann & Shappell, 2003). A total of 31 items from the original CSAS were retained, and an additional 16 items were included. The rationale behind the changing of the theoretical background to the questionnaire, the reasoning behind discarding items, and how the new items were selected is unknown to these authors. Nevertheless, this revision to the CSAS does not negate the research being carried out to link the nine years of CSAS data with mishaps. Rather, this research effort will either confirm the changes that were made to the CSAS, or offer guidance as to how the questionnaire can be further improved.

Gaba, Singer, Sinaiko, Bowen, & Ciavarelli (2003) compared the responses of health care respondents with those from Naval aviation. Aviators responded to CSAS and hospital workers to the Patient Safety Cultures in Healthcare Organizations (PSYCHO) survey. Both of these instruments have partially overlapping items, with 23 items from the PSYCHO adopted directly from the CSAS. The survey included employees from 15 hospitals and Naval aviators from 226 squadrons. For each question a "problematic response" was defined that suggested a lack of or antithesis to safety climate (Gaba et al., 2003). Overall, the problematic response rate for hospital workers was up to 12 times greater than that among aviators on certain items. These findings were true both for the aggregate of all health care respondents and, even more strikingly, for

respondents from particularly hazardous health care arenas (e.g., emergency rooms and critical care) the number of problematic responses were 16 times greater than among aviators.

However, the study did reveal a few similarities between hospital personnel and Naval aviators regarding specific safety climate features covered by the matched questions. In both sectors, respondents were highly uniform in their belief that their institution is committed to and has a good reputation for safety. They both expressed concern about the level of resources provided for them to accomplish their jobs, although health care workers were even more concerned than aviators about the effect on safety of a loss of experienced personnel. Nonetheless, for most questions across all aspects of safety climate, there were low rates of problematic response among Naval aviators (generally under 10%), but a much higher rate among health care workers, by a factor of three or more. Thus, the overall pattern of results suggests that the military safety climate is quite high compared to other HROs.

Desai et al. (2006) measured the relationship between recent accidents and perceptions of safety climate, as measured by the CSAS, on a large, cross-sectional sample of respondents in several Naval aviation squadrons. The notion was to understand potential cognitive and behavioral changes *following* accidents. They hypothesized that safety climate would improve after an accident occurred because actual changes in safety climate occurred, or cognitive bias (fundamental attribution error) occurs in which people are more likely to blame situational factors rather than people.

The study used the 6,361 responses from 147 Naval squadrons taking the online CSAS between July 2000 and December 2001. Aviation mishap information was collected from the U.S. Naval Safety Centre (the number of mishaps used was not reported). These accidents are measured by their intensity and are divided into Class A, Class B, and Class C mishaps. At the time of the research, the definition of a Class A mishap was damage of $1 million or more, or an injury or occupational illness resulting in a fatality or permanent total disability. Class B mishaps involve a total mishap cost of $200,000 or more, but less than $1 million, or an injury or occupational illness that results in permanent partial disability or for which three or more persons are hospitalized. Class C mishaps are accidents in which the total cost of reportable material property damage is $10,000 or more, but less than $200,000, a nonfatal injury that causes any loss of time from work beyond the day or shift on which it occurred, or a nonfatal illness or

disease that causes loss of time from work because of disability (Chief of Naval Operations, 2001).

The dependent variable was a safety climate perception construct developed by aggregating each individual's responses to the CSAS. Six independent variables were constructed to measure accidents prior to survey administration. These mishap variables were recorded at the squadron group level of analysis. All individuals within the squadron received the squadron value for these mishap variables for the present analysis.

Desai et al. (2006) regressed the safety climate construct on several indicator variables tracking the occurrence of accidents, grouped by their severity, in periods roughly one year prior to survey measurement and two years prior to survey measurement. Analysis indicated positive associations between minor or intermediately severe accidents and future safety climate scores, although no effect was found for major accidents. These findings suggest a generally positive association between minor or intermediately severe accidents and perceived safety climate. This study suffers in that only limited information was obtained on the mishaps. Also, although the number of mishaps that occurred during the period of study were not reported, the number was likely to be fairly low. Finally, the rationale that the safety climate will improve after a mishap may be flawed. If the squadron personnel believe that the causes of the mishap have not been addressed, it may be that the safety climate may go down, rather than improve, as suggested by Desai et al.

One unpublished study investigated whether the responses to the CSAS can predict aviation mishap rate. After some earlier encouraging analysis in support of the predictive validity of the CSAS, Schimpf and Figlock (2006) took the average (it is assumed that average refers to mean, although this is not stated) of the nine items from the risk assessment MOSE (the rationale for the focus on this particular MOSE was not provided), as well as the overall average of the 61-item CSAS for each respondent from August 2000 until October 2004. They divided the squadrons into quartiles based upon the average scores. They then counted the number of squadrons that had experienced a Class A mishap within 12 months, 18 months, and 24 months after taking the survey within each quartile (no explanation was provided for how squadrons that had completed the questionnaire on multiple occasions within this time period, or squadrons that

had multiple Class A mishaps, were handled). The data from this analysis are summarized in Figures 1 and 2.

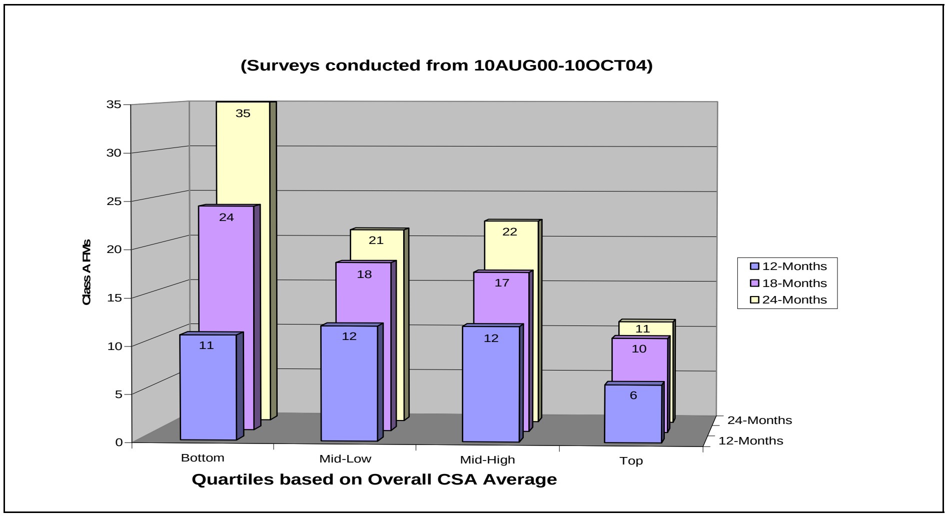

Figure 1. Class A mishaps within 12, 18, and 24 months after completing the CSAS (Quartiles by overall CSAS average; from Schimpf & Figlock, 2006).

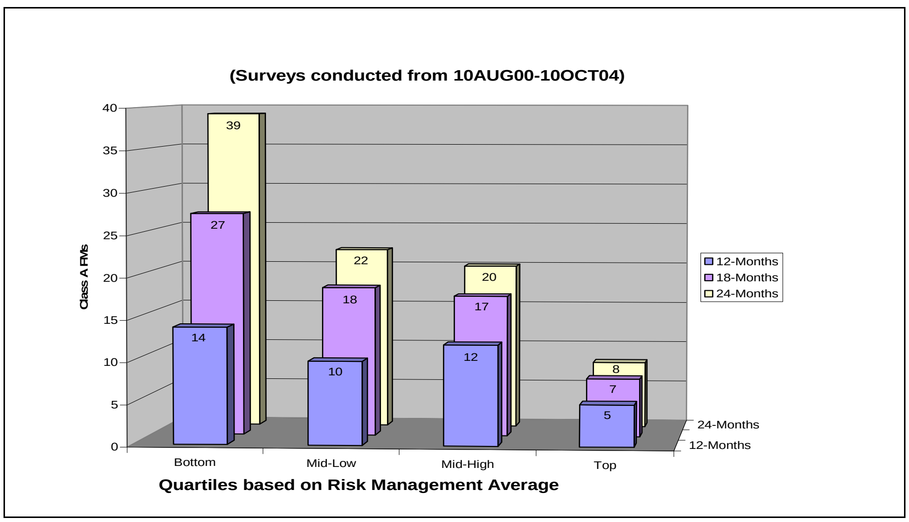

Figure 2. Class A mishaps within 12, 18, and 24 months after completing the CSAS (Quartiles by risk management average; from Schimpf & Figlock, 2006).

These findings are encouraging for the predictive validity of the questionnaire. However, collapsing the questionnaire data to the extent that was done in this study is a coarse method to examine whether the CSAS is a useful predictor of mishap probability. Reducing a sample size of some 3,355,000 questionnaire responses (i.e., approximately 55,000 responses to 61 items) to

four data points (i.e., quartiles) would seem to be a very wasteful use of data, and will result in a very large restriction in variability. Moreover, if items for which there is little variability are included to calculate the mean, as discussed above with reference to the MCAS, those items for which there are variance may be washed out. It would also have been of interest to have seen the mean and standard deviation of the quartile scores (these were not reported). The final concern is that the rationale for choosing the risk management scale is not provided. It would have been interesting to know what would have been produced using the same methods, but with the other scales. Schimpf and Figlock (2006) also concluded that MCAS item 34 (*I am provided adequate resources, time, personnel to accomplish my job*.) was also a good indicator of Class A mishap risk, using the same method as described above (again, the reason for focusing specifically upon only this item is not delineated).

In addition to the PCA described above, Adamshick (2007) also used the CSAS and MCAS to assess the relationship between leadership interventions and a respondent's safety climate assessment. Most pertinent for this review were results regarding CSAS item 42 (*my command provides a positive command climate that promotes safe flight operations*) and MCAS item 7 (*our command climate promotes safe maintenance*). For CSAS item 42, the following rank/demographic differences emerged among Navy and Marine respondents: senior officers reported significantly higher scores than junior officers; among pilots, those with more than 2,000 flight hours reported significantly higher scores than those with fewer hours, especially those who had between 500 and 1,000 flight hours. In addition, Navy department heads reported significantly higher scores than nondepartment heads and, among Marines, differences emerged between reservists in the following order: driller reserves had higher scores than active reserves, who, in turn, reported higher scores than regular status respondents.

For MCAS item 7, rank differences occurred among Naval respondents, in which officers tended to report higher scores than enlisted; among enlisted, the higher the rank, the higher the score. Work frame differences also emerged, in which respondents in maintenance control had the highest scores, whereas avionics reported significantly lower scores than most other work frames. As would be expected, night shift respondents reported lower scores than day shift respondents.

Adamshick (2007) suggests a variety of reasons for these demographic differences. For example, rank differences may be due to senior officers' bias in rating programs for which they are responsible. Junior enlisted may be more frustrated than senior enlisted due to increased responsibility, yet not commensurate rank increase. Regarding the response difference by number of total flight hours, it may be that those pilots with 500-1,000 hours are no longer novice pilots that find flying challenging and, at the same time, have started to have some authority. Adamshick also points out that greater flight hours are positively correlated with rank and authority.

Adamshick's (2007) results also indicate that perceived leadership factors positively associated with safety climate differ between officers and enlisted. For officers, four factors emerged:

1. use Human Factors Boards (a regular proactive, informal review of all officer and enlisted aircrew; see O'Connor & O'Dea, 2007 for more details);
2. leadership that encourages and enables individuals to report unsafe behaviors;
3. leadership that successfully communicates safety goals to personnel; and
4. leadership that reacts to unexpected changes.

For enlisted respondents, three leadership factors were positively associated with safety climate:

1. leadership adequately reviews and updates safety procedures;
2. leadership does not tolerate unprofessional behavior; and
3. leadership uses comprehensive and effective safety education and training programs.

Thus, in comparison to the Schimp and Figlock (2006) report, Adamshick's results suggest that a finer-grained analysis of the CSAS and MCSAS is merited.

G. CONCLUSION

It is argued that safety culture surveys can retrieve information that is not accessible through other more traditional methods of analysis, such as audits and risk assessments. Bailey and Petersen (1989) concluded that the effectiveness of safety programs cannot be measured by the more traditional procedural-engineering criteria popularly thought to be factors in successful programs. They argue that a better measure of safety program effectiveness is the response from

the entire organization to questions about the quality of the management systems that have an effect on human behavior relating to safety. They further concluded that perceptions surveys can effectively identify the strengths and weaknesses of a safety system's elements. However, for a safety climate survey to be useful, it must have construct and discriminate validity.

It is suggested that a comprehensive assessment of the validity of the CSAS is long overdue. The construct validity of the questionnaire has never been established, and there is only weak evidence supporting the discriminate validity of the tool. There is no specific proof that the CSAS is not identifying "at risk" squadrons. However, there is also no strong evidence that it is supplying helpful information to leadership. In the absence of a valid tool, time and money is being wasted administrating the survey. However, most importantly, the opportunity of preventing mishaps by providing useful feedback to leadership is being missed.

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